Preparation of PIM1

PIM material (PIM1) was prepared from the monomers 5,5',6,6'-tetrahydroxy-3,3,3',3'-tetramethyl-1,1'-spirobisindane and tetrafluoroterephthalonitrile generally according to the procedure reported by Budd et al. in *Advanced Materials*, 2004, Vol. 16, No. 5, pp. 456-459. 100.00 grams of 5,5',6,6'-tetrahydroxy-3,3,3',3'-tetramethyl-1,1'-spirobisindane were combined with 59.219 g of tetrafluoroterephthalonitrile, 243.6 g potassium carbonate, and 2543.6 g of N,N-dimethylformamide, and the mixture was reacted at 68° C. for 72 hours. The polymerization mixture was poured into water, and the precipitate was isolated by vacuum filtration. The resulting polymer was twice dissolved in tetrahydrofuran, precipitated from ethanol, and air dried at room temperature. A yellow solid product was obtained having a number-average molecular weight of approximately 40,800, as determined by gel permeation chromatography analysis using light scattering detection.

Example 1

a) A commercial 22-nF (22-nanofarad) ceramic capacitor (part #C340C223J2G5CA from Kemet Electronics Corporation, Greenville, S.C.) was cut in two near the wire leads (resulting in a capacitance of 0.488 nF) using a low speed diamond saw in a direction substantially perpendicular to the wire leads. The capacitor had 24 interdigitated metal fingers with a 35 micron pitch and separated by ceramic layers. The portion having the wire leads attached was used in the following procedure. As a control step to show that the comparative capacitance sensor prepared above is operational, the sensor was baked for one hour at 150° C., before it was placed inside a test chamber and exposed to several levels of relative humidity. The sensor showed a high response to humidity, achieving a $\Delta C/C_O$ (i.e., the change in capacitance from the initial value divided by the initial value) value of 0.25 at 80 percent relative humidity. In a separate experiment, the sensor was substantially non-responsive when exposed to acetone vapor introduced into the test chamber (i.e., $\Delta C/C_O$ was essentially zero). The sensor was then was baked for one hour at 150° C., and placed inside the test chamber. Exposure to acetone vapor with concentrations up to at least 4000 ppm showed no change in capacitance ((i.e., $\Delta C/C_O$ was essentially zero).

b) The capacitance sensor made in a) was soaked in 5M sodium hydroxide in water/ethanol (2:1 ratio) solution for 6 days. After soaking, the sensor was carefully washed in distilled water, and dried to remove any residue. It was observed that a small amount of the ceramic was removed, and most of the ceramic was still present. To determine how the etching affected the ceramic sensor the baseline capacitance before and after soaking in the sodium hydroxide solution was compared. The capacitance changed from 488 to 367 pF. To show that the change was not just damage to the sensor, but rather a systematic removal of the ceramic material another humidity test was run with the sensor. After one hour at 150° C. in the oven the sensor was placed inside a test chamber and exposed to several levels of percent relative humidity. The etched capacitance sensor showed a high response to humidity, achieving a $\Delta C/C_O$ (i.e., the change in capacitance from the initial value divided by the initial value) value of 6.6 at 80 percent relative humidity. Clearly, the etched capacitor was much more sensitive to humidity than the non-etched one. Exposure to acetone vapor with concentrations up to at least 4000 ppm showed no change in capacitance ((i.e., $\Delta C/C_O$ was essentially zero).

c) A four percent solution of a PIM1. The solution was prepared in chlorobenzene by mixing the components in a vial and placing it on a roller mill overnight to complete the dissolution of the materials and then filtered through one micrometer pore size filter. The PIM1 solution was applied directly on the etched surface the etched capacitance sensor prepared in b) using a small artist's brush, and then dried for one hour in a 100° C. oven. This procedure was repeated twice. The resultant variable capacitance sensor was tested for response to acetone vapors. After baking for one hour at 150° C., the sensor was placed inside a test chamber, and exposed to acetone vapor. At an acetone vapor concentration of 4000 ppm, the capacitance sensor exhibited a $\Delta C/C_O$ of 0.0012, with detectable differences in capacitance observed at acetone levels of 50 ppm or less. Clearly, by replacing just a portion of the ceramic layer with absorbing microporous material like the PIM in this example, we were able to increase the sensitivity of the variable capacitance sensor toward acetone.

All patents and publications referred to herein are hereby incorporated by reference in their entirety. All examples given herein are to be considered non-limiting unless otherwise indicated. Various modifications and alterations of this disclosure may be made by those skilled in the art without departing from the scope and spirit of this disclosure, and it should be understood that this disclosure is not to be unduly limited to the illustrative embodiments set forth herein.

What is claimed is:

1. A variable capacitance sensor comprising:

a first conductive electrode comprising electrically interconnected first conductive sheets;

a second conductive electrode comprising electrically interconnected second conductive sheets, wherein the first conductive sheets are at least partially interleaved with the second conductive sheets, and wherein the second conductive electrode is electrically insulated from the first conductive electrode;

a ceramic material at least partially disposed between and contacting the first conductive sheets and the second conductive sheets; and

microporous dielectric material at least partially disposed between and contacting the first conductive sheets and the second conductive sheets.

2. The variable capacitance sensor of claim **1**, wherein the microporous dielectric material comprises a polymer of intrinsic microporosity.

3. The variable capacitance sensor of claim **1**, further comprising an encapsulant layer covering a portion of the first and second conductive electrodes.

4. A method of making a variable capacitance sensor, the method comprising steps:

a) providing a ceramic capacitor comprising:

a first conductive electrode comprising electrically interconnected first conductive sheets;

a second conductive electrode comprising electrically interconnected second conductive sheets, wherein the first conductive sheets are at least partially interleaved with the second conductive sheets, and wherein the second conductive electrode is electrically insulated from the first conductive electrode; and

ceramic material at least partially disposed between and contacting the first conductive sheets and the second conductive sheets; and